The IoT Nation 2018

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Produced by

iotUK

Introduction

The UK aims to be a global leader in the Internet of Things (IoT). The objective is to increase the adoption of high quality IoT technologies and services across the public and private sector in the UK.

The Internet of Things is a transformational technology capable of creating new business opportunities for some and enabling organisational change in others.

The IoT will bring new possibilities for the UK population; how is the spread of IoT companies across the UK helping to deliver this opportunity?

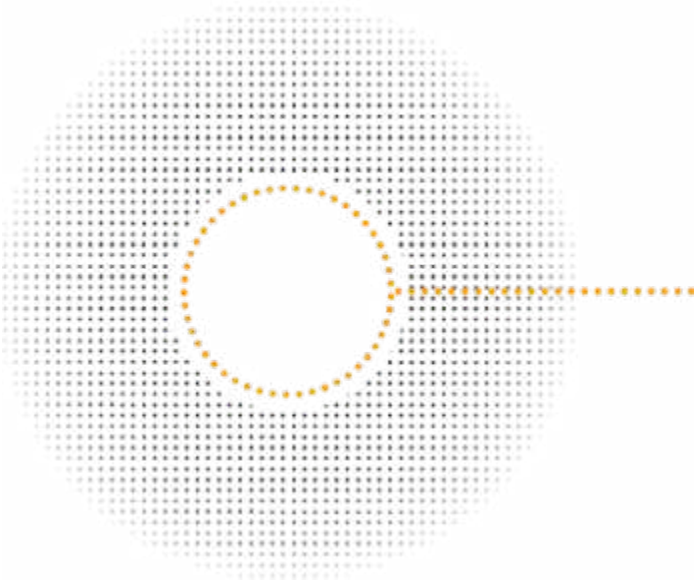
In this report, we will look at sections of the UK's IoT ecosystem and identify the key places of the growing network of IoT businesses, academic institutions and public bodies.

Using innovative data science techniques, we have shown that:

- Universities are having an impact on IoT development, particularly in Oxford, London and Cambridge.
- Logistics is driving much IoT innovation in the UK.
- Public sector investment in IoT helps drive innovation.

Our aim with this database is to:

- understand the resilience of the sector and its ability to continue to grow and evolve to meet changing demands
- spot opportunities to maximise the impact that IoT can have for UK citizens
- describe the impact that the IoTUK programme is having on the UK's Internet of Things sector.



Front cover: ODI Leeds

Context

Our aim in this report is to:

- identify the role that Academia and Industry play in the growth and development of the UK Internet of Things sector
- analyse the strength of collaboration between public and private sector organisations in delivering innovation in IoT
- understand the resilience of the sector and its ability to continue to grow and evolve to meet changing demands
- spot opportunities to maximise the impact that IoT can have for UK citizens
- describe the impact that the IoTUK programme is having on the UK's Internet of Things sector

SIC Codes

The established way to understand an economic sector is to use Standard Industrial Classification codes, or SIC codes for short. For example, if a business is interested in businesses making cement, they could generate a list of businesses for analysis by searching for those with a SIC code of 23510: the Manufacture of Cement.

This cannot be done for the Internet of Things as there is no SIC code for the sector.

SIC codes were developed in 1937 by the US government as a way of classifying "industries". Over the years various classifications have been used, with the US and UK systems differing in detail as requirements have changed.

The UK has updated its SIC codes seven times to reflect how industries have changed. The latest update happened in 2007 and this version contains 15,599 different industry descriptions, mapped to 728 different code numbers.

The first academic paper to be tagged with the 'Internet of Things' keywords in the Microsoft Academic Graph dataset is from 1990[1]. The first paper to explicitly use the phrase 'Internet of Things' was published in Scientific American in 2004[2].

It is perhaps no surprise that the latest version of SIC codes does not contain a code for the "Internet of Things". The term was in its infancy at the time the last revision was published.

There are references to internet publishing, internet sales, internet broadcasting but nothing for the use of the Internet as an enabling technology for other devices. The closest code we find is 63120: the operation of web portals.

The Internet of Things is less about a sector specific discipline and more about the application of technology to a wide range of problems. It is, therefore, no surprise to find that there are 228 different SIC codes used by the 1,344 businesses in the database.

The most popular is 62090 – used to describe a business which does software consultancy and/or programming. There are 365 businesses which describe themselves as involved in "Software Consultancy", 95 in "telecommunications" and 46 in "scientific research and development".

Digital Catapult's IoTUK programme commissioned The Datacity to build an open data asset designed to curate the UK's IoT business information in one place. This is needed because there is no way to use existing business lists to find all IoT businesses.

This data set, the IoTUK Nation Database, is published openly under an Open Data Commons Open Database License. It was launched in 2017 and a refreshed version for 2018 is available, with updates having taken place in April and July. The insight in this report is derived from the 2018 version of the IoTUK Nation database.

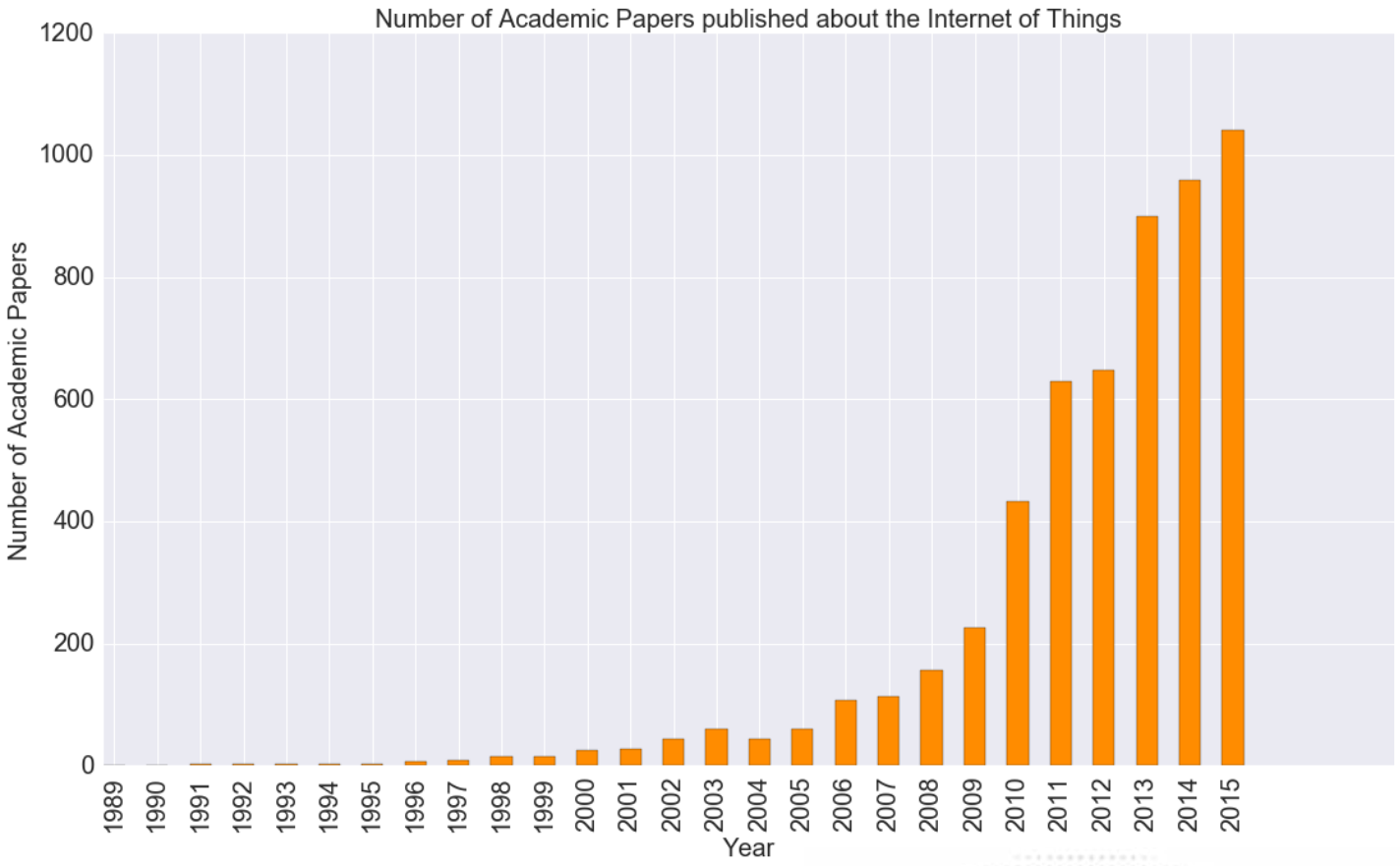
This report was first published in March 2018 and has been updated in July, following the publication of the updated data files on Data Mill North.

THE DATA CITY

[1] https://www.researchgate.net/publication/3495532_Use_of_ALE_and_packet_radio_for_HF_networks

[2] http://cba.mit.edu/docs/papers/04.10.i0.pdf

Context


Number of Academic Papers published about the Internet of Things
Number of Academic Papers
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Methodology

The IoTUK Nation database

The IoTUK Nation Database brings together a snapshot of the current state of the organisations that make up the Internet of Things sector in the UK. We've created the database using open data and the power of "the web of data" to collate and cross-reference information from a variety of sources.

In the absence of existing markers that help us identify a business engaged in the Internet of Things sector, the database has been built by harvesting information from a range of sources to produce an open dataset of businesses involved in the Internet of Things.

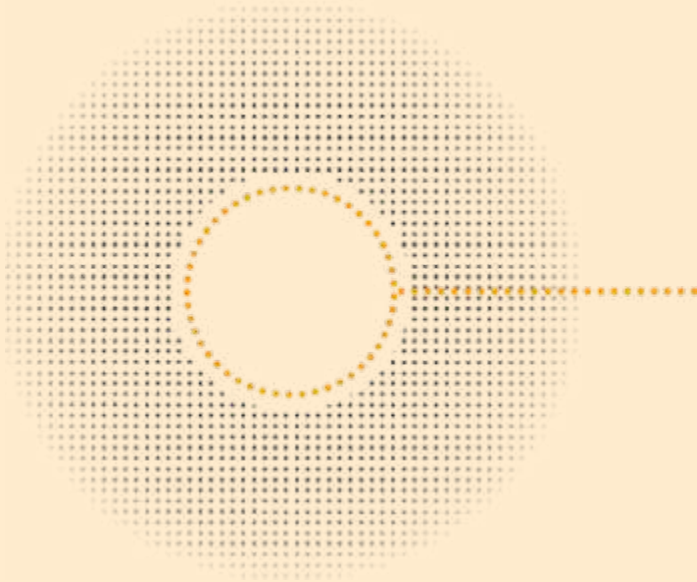
These sources include Companies House data, data from the Microsoft Academic Graph, information from meet up platforms and social networking sites and descriptions of the business' own activities from their website. Other open datasets, such as the funding available from funding councils and the activities of the Catapults', have also been used in producing this dataset.

The data science team at The Datacity have built a set of algorithms that merge the available data and look for evidence that an organisation is involved in the Internet of Things.

The artificial intelligence sifts through all the available data about an organisation and decides, based on patterns seen from previous organisations, how likely it is that the organisation is engaged in Internet of Things activity.

The IoTUK Nation Database contains attributes of UK organisations engaged in IoT activities. These attributes include the name, address and sector along with other information that helps us describe the activities of the organisation. We publish this database openly so that errors and omissions can be flagged by the IoT community to assist us in producing a valuable data asset capable of describing the complexities of the sector. The database is published in a flat CSV format and is hosted at the Data Mill North open data repository.[3]

As of 31st July, there are 1,344 organisations in the IoTUK Nation database. As the underlying algorithm has been refined, the database has grown from 603 organisations in 2017 and 972 organisations in March 2018.



[3]https://datamillnorth.org/dataset/iotuk-nation-database

Methodology

Our Process

The process starts with a set of possible organisations, such as a list of all UK universities, all government departments and NHS Trusts. The algorithms look to partition the organisations into two sets: those that are engaged with IoT activities and those that aren't. The algorithm does this based on the probability score calculated by the artificial intelligence engine.

A list of businesses known to be active in the IoT sector is used to train the artificial intelligence engine to spot other IoT businesses. The artificial intelligence uses its knowledge of what attributes these known IoT business have, such as the words they use to describe themselves on their website, to help predict whether another business is active in the sector.

Our process has learnt that a business with "sensor" in the name could be an Internet of Things business but the process needs to calculate a specific probability for the individual business.

At a workshop held in Leeds in October, we spent time agreeing the boundaries of the Internet of Things. The delegates at this session debated how we could define the subtleties of what is in, and out, of the set of all IoT businesses. The information collected at this session has been fed back into the data set used to train the artificial intelligence engine. As expected, the key features are that businesses must have some kind of real time or batch sensing features which are transmitted over the Internet.

Cisco are an international networking and telecommunications business that mention the Internet of Things on their homepage. There is no doubt that this business is involved in the sector as the words they use to describe their business activities explicitly includes the phrase "Internet of Things".

There are other organisations, such as Invisible Systems, whose homepage does not explicitly mention the Internet of Things even though the organisation is involved in the sector. However, the phrases used, such as "sensors for monitoring energy", are identified by our artificial intelligence engine as being relevant to the domain and the business is therefore flagged as being in the sector.

[4]http://ieeexplore.ieee.org/document/7109842/

The word sensor is sometimes misleading if we use it to determine whether an organisation is engaged with IoT activities. For example, the home page of Sensor Coatings Systems Ltd mentions sensors but our algorithm concludes that there are not actually active in the IoT sector. The business makes coatings which can be used to establish the temperature of materials but the readings are taken manually and there is no real time internet enabled feedback mechanism.

We use artificial intelligence to remove the need for a human to check every organisation we want to classify.

Rich insight

The multiple data sources used to produce the IoTUK Nation database enable The Datacity to derive rich insight from the raw data. As well as identifying the geographic clusters of organisations we can start to link organisations to identify other cluster types.

For example, two universities may be connected because they have collaborated on a research paper.

By way of a specific example, and we may choose from many similar examples, consider the paper, published in 2015, by authors from Queen Mary University London, the University of Southampton and the Fraunhofer Institute of Optronics in Karlsruhe in Germany.

The paper, A Semantic IoT Early Warning System for Natural Environment Crisis Management[4], discusses research into the Internet of Things. Our artificial intelligence engine correctly flags this paper as being relevant to the Internet of Things and includes both UK universities in the IoTUK Nation database. We can, therefore, use this research article as a single piece of evidence to confirm that Queen Mary University and the University of Southampton are involved in the Internet of Things sector.

Our algorithms are looking for multiple "votes" – that is many pieces of evidence that confirm that an organisation is involved in the sector.

Methodology

Having a clear picture of how organisations are connected allows us to treat the ecosystem as a mathematical network. This allows us to model how strong the connections are between organisations in the IoT sector and look for patterns that help us understand how resilient the network is to change.

What would happen if business A is removed? How important is organisation B to the diffusion of innovation?

Using novel mathematical algorithms developed by The Datacity team, in collaboration with the Universities of Oxford and Strathclyde[5], we can quantify the strength of connection in the network. This enables us to understand the most important parts of the ecosystem and much of our insight in this report is based on this mathematical understanding of the connections in the IoT ecosystem.

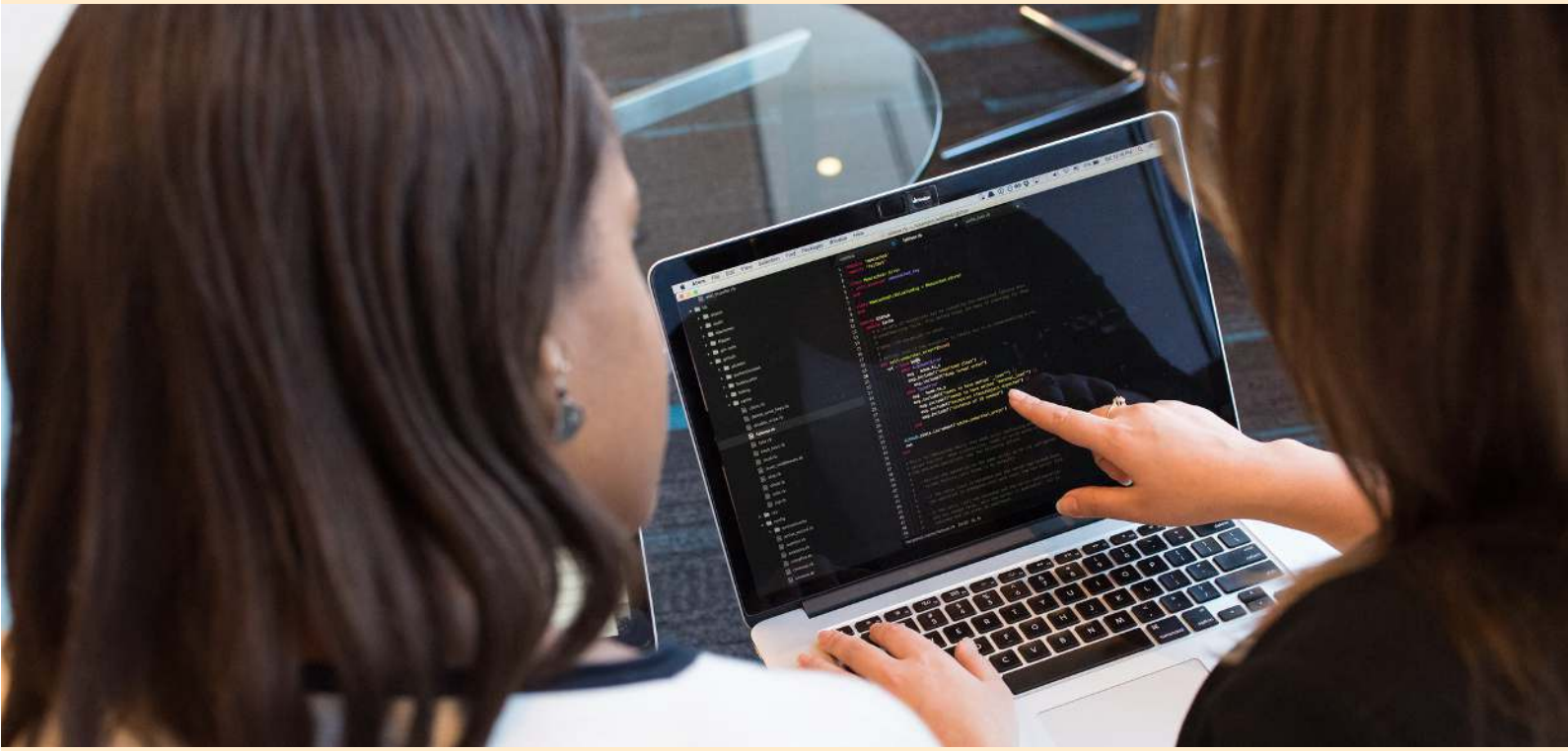


Image credit: womenintechchat.com

Geographies

Identifying individual companies enables us to locate where they have their main trading address, thus providing a detailed spatial element to support policy development and investments. One of the additions made to the July 2018 version of the IoTUK Nation database has been to include two additional geographical lookups. The NUTS3 (NUTS stands for Nomenclature Unités Territoriales Statistiques) coding system provides a European standard for the administration and reporting of public sector activities. Although in some areas the NUTS3 code maps directly on top of a local authority region, for example in Leeds where the UKE42 code covers the Leeds local authority area, there are areas of the country where more than one local authority area is included in one NUTS3 region. An example is in Central London where the boroughs of Haringey and Islington are contained in the same NUTS3 region of UKI43. In total, we have 29 organisations within this NUTS3 region.

In order to assist in the analysis of this dataset by local authority region, we have now included the local authority areas too, so that businesses can be analysed by local authority area and NUTS3 region.

Analysis by local authority areas, shows that 27 organisations in Islington and 2 in Haringey.

As a final step towards easier analysis, we have also included the Westminster Constituency in the data, allowing analysis between parliamentary areas. Islington South and Finsbury has 25 organisations.

When we analyse the data by NUTS3 regions alone, we find that 120 of the 1,344 businesses are within the Camden and City of London region. This tells us that nearly 9% of the organisations involved in IoT in the UK are based in this area in Central London.

Analysis by Westminster Constituency reveals 138 organisations in the Cities of London and Westminster constituency. If we analyse by local authority area, we find 71 are in the London borough of Westminster and 69 are in the borough of the City of London. The boundaries of local authorities and Westminster constituencies, and those of the NUTS3 regions, do not match up exactly and so the ability to analyse across these boundaries will be helpful to us in finding the stories we wish to tell.

Whilst knowing that Camden and the City of London is the NUTS3 region with the largest number of organisations involved in the Internet of Things is a useful measure, how does this compare to the number of businesses in this region, regardless of their activities?

Analysis of UK business data shows there are approximately 100,000 businesses registered in the NUTS3 region. A quick calculation reveals that there are 12 IoT businesses for every 10,000 in the Camden and City of London NUTS region.

Compare this with the Cambridge CC NUTS3 region, UKH12. There are 54 IoT organisations in our dataset and approximately 19,000 businesses in the area. For every 10,000 businesses in the Cambridge CC area, there are 29 IoT businesses. Cambridge is the NUTS3 region with the highest density of IoT businesses in the country.

Geographies

NUTS3 Region	Per 10,000 businesses
Cambridgeshire CC	29
Berkshire	24
Tower Hamlets	19
Oxfordshire	18
North Hampshire	15
West Surrey	14
Leeds	13
Lewisham and Southwark	13
Camden and City of London	12
Westminster	11
Greater Manchester South West	11
Bristol, City of	11
Bath and North East Somerset, North Somerset, and South Gloucestershire	10
Central Hampshire	10
Milton Keynes	10
West Essex	10
Harrow and Hillingdon	9
Hackney and Newham	9
Edinburgh, City of	9
Liverpool	9

Westminster	Per 10,000 businesses
Cambridge	74
Maidenhead	44
Oxford East	36
Hayes and Harlington	31
Hackney South and Shoreditch	30
North Tyneside	29
Runnymede and Weybridge	28
South East Cambridgeshire	27
Bracknell	27
Reading West	27
Wokingham	25
South Cambridgeshire	25
Guildford	24
Bermondsey and Old Southwark	23
Romsey and Southampton North	23
Wantage	23
Leeds Central	22
Windsor	22
Harlow	22
Bristol West	21

For an area to be included in these tables, it must have at least 10 IoT organisations per NUTS3 and Local Authority Area or 5 organisations per Westminster Constituency.

Geographies

Local Authority	Per 10,000 businesses
Cambridge	72
Windsor and Maidenhead	44
Runnymede	35
South Cambridgeshire	33
Oxford	29
Tower Hamlets	20
Reading	20
Hackney	18
City of London	17
Southwark	17
Wokingham	17
Hillingdon	16
Trafford	15
Wycombe	15
Leeds	13
Westminster	11
Bristol, City of	11
Lambeth	10
City of Edinburgh	9
Liverpool	9

For an area to be included in these tables, it must have at least 10 IoT organisations per NUTS3 and Local Authority Area or 5 organisations per Westminster Constituency.

From these tables, we form the view that the top 10 areas for IoT in the UK (as measured by the number of IoT organisations per 10,000 businesses) are:

- Cambridge
- M4 Corridor
- Oxford
- Central London
- Southampton
- Leeds
- Bristol
- Edinburgh
- Liverpool
- Nottingham

Cambridge & Oxford – a diverse mix of research, investment and application driven by the University

There are 31 organisations each within 3 miles of each other in the centre of Cambridge. Cambridge has a range of business sizes, with 11 Micro businesses, 9 SME, 3 medium size and 1 Large business. It has a world leading University and the IoT organisations are active across a range of industries. Cambridge is home to organisations who build hardware for IoT, write software for IoT applications and organisations who fund IoT through investment programmes. However, we also see application businesses, such as organisations using IoT in agriculture and analytics domains. Cambridge is home to a diverse range of organisations using IoT, with many having using IoT to transform their existing business rather than using it to set up a new one.

Oxford is also home to a world leading University and the higher than expected number of IoT organisations can be traced back to spin outs from the University.

M4 Corridor – fuelled by logistics and the existing tech companies

The area with a higher than expected density of IoT organisations starts at Heathrow, driven mainly through the logistics sector focused around Europe's busiest airport, and spreads as far west as Swindon. The activity focused around Heathrow is covered by the Hayes and Harlington constitutency and the area has a very high density of IoT businesses with the likes of British Airways, Cargologicair and Menzies Aviation all having their head office locations close to the airport. Many technology companies based in Maidenhead, Reading and Newbury have an interest in IoT.

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Geographies

Central London – Home to the registered offices for application companies

A large proportion of the IoT businesses based in London are focused around the area of London from City Road in Shoreditch and the area just north of the City of London. The majority of these organisations are application companies, using IoT in their products or services.

Other areas of interest include Southampton, where mapping providers Garmin and Ordnance Survey are based. Leeds has a vibrant mix of logistical businesses, including the Dart Group that operate Jet2 and Fowler Welch, infrastructure businesses such as AQL and IX Leeds and businesses that innovate with the data IoT produces. Bristol is home to a number of tech recruiters specialising in IoT recruitment as well as hardware and software companies and Liverpool's interest in IoT is focused around application development and the logistics required to operate a world leading port facility.

What is noticeable as you move down this list of focus areas for IoT is that the diversity of the IoT ecosystem drops. In Cambridge and Oxford, you have a mix of industries, where hardware, software, domain specific implementations such as in Agriculture and R&D come together in a microcosm of innovation. These are complex systems, where organisations feed each other and it can be hypothesised that the factors for growth can be linked back to a growing community of skilled individuals providing a critical mass for further development. The maturity of this system is not seen in such detail in other parts of the UK.

IoT businesses that provide logistics support will be located close to the infrastructure they require, such as airports or motorways. Businesses supported by investment will likely be registered in the City of London or Shoreditch.

Away from Cambridge, Oxford and London, there is a sense that cities are trying to lay claim to being the home of a specific application of IoT technology. Time will tell whether organisations cluster in specific ways across the country based around applications or whether it is just too early to tell if these are meaningful patterns or not.

However, we can conclude that a town looking to bring IoT investment to their city would do well to analyse in detail how Cambridge has been successful and look to use that thinking in their local development planning.

Conclusion

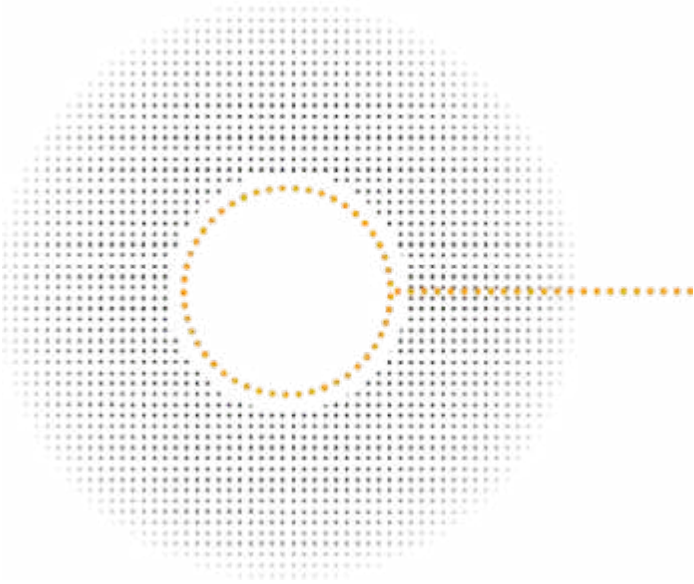
The geographic results allow us to explore in more detail where the IoT businesses are making an impact. It comes as no surprise that the spin-outs from Oxford and Cambridge Universities that are working on cutting edge technology means that these regions feature highly in the tables of IoT businesses. With applications from across a range of sectors and a culture of interconnectivity coming from academia, it has allowed the businesses here to start and to grow.

Another key driver for IoT innovation is the M4 corridor. The IoT has demonstrated that it increases productivity in delivery and supply chain performance, and many logistics companies are being created that use IoT to improve systems and supply networks, reduce costs, and find new opportunities for established businesses to generate more revenue.

Smart city projects are also having an impact on IoT. Where local councils are investing in IoT through establishing LPWAN networks and business development programmes aimed at innovation such as Leeds and Southampton, we can see a proliferation of IoT businesses. Are the councils responding to the need, or are they creating the drive? It is difficult to tell from the data as yet.

When we look at the connectivity of the businesses involved in the IoT sector we see that the businesses focused on IoT cross multiple sectors. They connect disconnected parts of the economy together in a way that will help facilitate growth, innovation and the diffusion of valuable ideas, products and services.

Programmes like Digital Catapult's IoTUK programme have helped drive innovation in IoT across the UK by investing in the areas that are seeing clusters of IoT activity, amplifying and driving IoT innovation here and taking those innovations to a wider audience through their work.



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